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Abstract: Epilepsy is both a disease of the brain and the mind. Here, we present the second of two papers with extended summaries of selected presentations of the Third International Congress on Epilepsy, Brain and Mind (April 3-5, 2014; Brno, Czech Republic). Humanistic, biologic, and therapeutic aspects of epilepsy, particularly those related to the mind, were discussed. The extended summaries provide current overviews of epilepsy, cognitive impairment, and treatment, including brain functional connectivity and functional organization; juvenile myoclonic epilepsy; cognitive problems in newly diagnosed epilepsy; SUDEP including studies on prevention and involvement of the serotoninergic system; aggression and antiepileptic drugs; body, mind, and brain, including pain, orientation, the "self-location", Gourmand syndrome, and obesity; euphoria, obsessions, and compulsions; and circumstantiality and psychiatric comorbidities.

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Phenomenology of phantomology: lessons from epilepsy.

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The term "Phantomology" was introduced by Polish science fiction writer Stanislaw Lem [1]. It designates the study of the virtual reality of the human body and is a visionary anticipation of modern virtual reality technologies. Used in the context of behavioral neurology, "phantomology" is the science of the body-in-the-brain [1], a body which manifests itself, on the phenomenological level, as phantom phenomena. Phantom phenomena are reported after amputation, in congenital absence of a limb [3], but also after deafferentation at all levels of the nervous system, i.e. after spinal cord injury [4] and in the course of subcortical and cortical lesions, where the propagation of somatosensory signals is interrupted at the central level, i.e. between primary sensory input areas and higher-order areas of the representation of the body as a whole. It is at this high level of disruption of bodily awareness that we can learn most from epileptic disorders. We present a selective review of the literature, with a special focus on phantom phenomena occurring with seizures.

Supernumerary phantom limbs and epilepsy

The awareness of an illusory "extra limb" is not infrequent after stroke, even if patients are sometimes reluctant to spontaneously report it [5]. Russel and Whitty [6] described three patients with a supernumerary phantom limb in traumatic epilepsy with parietal lesions. An illustrative case report of a man with new-onset attacks consisting in the experience of a left extra arm and leg was recently reported [7]. The supernumerary phantoms were the only manifestations of the seizures, whose origin could be tracked to the right parieto-temporal junction by ictal SPECT (EEG and MRI were nonlocalizing). The case report is also illustrative in a literal sense: it is accompanied by a drawing of the phantom percept sketched by the patient himself, a way of "picturing the invisible" to be preferred over artists' drawings [8].

"Whole-body phantoms" and epilepsy: autoscopic phenomena

The phenomenological classification of autoscopic phenomena [9] lists six major types: the "feeling of a presence", the autoscopic hallucination, heautoscopy, negative and inner heautoscopy and the out-of-body experience. All these subtypes of an illusory reduplication of the bodily self have been reported as an epileptic manifestation.

Feeling of a presence

The "feeling of somebody being nearby" [10] is a classic ictal phenomenon. It is most similar to the phantom limb experience in that it lacks visual quality, yet, the localization of "the other" in space is as precise as that of a phantom limb. This "invisible *doppelgänger*" [11] is often confined to one side of the body, but even in cases with a strictly unilateral seizure focus, the phenomenon is not necessarily lateralized [12] or is experienced ipsilesionally [13]. For the experimental evocation of a "presence" by electrocortical stimulation see ref. [14].

Autoscopic hallucination and heautoscopy

An autoscopic hallucination is the experience of seeing an image of oneself while one's observer's perspective is unambiguously centered on the body. Heautoscopy refers to the

encounter with a double of oneself, while typically, the patient is at a loss to decide where "the real me" is located. This taxonomic distinction may seem picky, but has recently received support by lesion-symptom mappings [15]. The major lesion site is the right extrastriate cortex in autoscopic hallucinations (in accordance with focus localization in early case reports; 16; 17), but the left posterior insula and parietal cortex in heautoscopy. Insular involvement may account for the highly complex psychological interactions between patients and their doubles, whether described in the belletristic accounts of famous writers with epilepsy (ref. 18 for overview) or as reflected in the comparably dramatic contents of seizure equivalents [19; 20]. In the epilepsy literature, the distinction between these two subtypes of autoscopic phenomena is rigorously followed by some authors (e.g., 21; 22), but unfortunately not by others [23].

Negative and inner heautoscopy

Negative heautoscopy is the experience of not seeing one's body when looked at directly (or in a mirror), despite otherwise preserved visual perception. In epilepsy, the phenomenon was labeled "asomatoscopy" [24] to emphasize its conceptual similarity to asomatognosia, which is a more frequent phenomenon experienced during seizures [25]. Inner heautoscopy means the visualization of *one's own* internal organs in extracorporeal, peripersonal space. Phantom sensations do exist for internal organs [26], and inner heautoscopy may constitute a synesthesia-like visualization of coenesthetic sensations [27]. Modern descriptions are rare; perhaps due to mixing the phenomenon up with an entirely different phenomenon, i.e. "x-ray vision", the demonstrably false claim to see *other* peoples' inner organs [28].

Out-of-body experiences (OBEs)

Descriptions of OBEs have a long tradition in parapsychology [29], but scattered reports have always been around in the neuropsychiatric literature as well, especially in connection with seizure disorders [30; 31]. Neuroscientists' and philosophers' interest in phenomenon has exponentially increased [32; 33] after a seminal Nature paper in the year of 2002 [34]. This report described the experimental induction of an OBE by electrocortical stimulation over the parieto-temporal junction during presurgical epilepsy evaluation. Evoked-potential mappings during visual perception and perspective-taking tasks proved useful to pinpoint, in the healthy brain, critical stages of the experience and to delineate the mechanisms underlying various phenomenological details of an OBE [35]. In patients, methods to localize a seizure focus are similarly important to identify those neocortical structures involved in the mediation of single elements of one of the most complex phantom body experiences [36].

Conclusion

Seizure disorders provide a rich source of insight for the field of phantomology. The study of focal and complex-partial seizures reveals a broad phenomenology of altered perceptions of body and self, and seizure localization helps attributing certain symptoms to underlying neural circuits. In addition, since Wilder Penfield [37], experimental evocations of phantom phenomena in the frame of presurgical evaluations have repeatedly contributed to a better understanding of how the body is represented in the brain and how the self is hooked up with the body. Finally, the "psychiatric" components of phantom limbs and bodies are best reflected in the phenomenology of temporal-limbic seizures, and as "psychiatry is but neurology of the limbic system" (ref. 38, p.603), many apparently "purely" psychological complexities associated with autoscopic phenomena (e.g. ref. 39) may well turn out to be the expression of limbic hyperactivity. In brief, epilepsy research can formidably elucidate the varieties of extracorporeal experiences – from phantom limb to phantom body [40].

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